Potential Impact of Open Architecture on AEGIS

Using KVA and Real Options Analysis

14 May 2008

Dr. Thomas Housel and Dr. Jonathan Mun
Naval Postgraduate School

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
14 MAY 2008		**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Potential Impact of Open Architecture on AEGIS Using KVA and Real Options Analysis	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
5th Annual Acquisition Research Symposium: Creating Synergy for Informed Change, May 14-15, 2008 in Monterey, CA

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**20**	

Overview

- Introduction
- Knowledge Value Added (KVA) and Real Options Analysis
- KVA + RO Valuation Framework
- Case Study Methodology
- The Challenge
- AEGIS Software Maintenance and Upgrade Process
- AEGIS On-Ship and Off-Ship Processes
- AEGIS Off-Ship Sub-Processes
- KVA Methodology Process Steps
- Case Study Results: Potential Impact of OA
- Case Study Results: Revised Processes
- Case Study Results: Cost, ROI and Revenues
- Real Options Analysis
- Real Options Results: Strategies A-D
- Research Implications

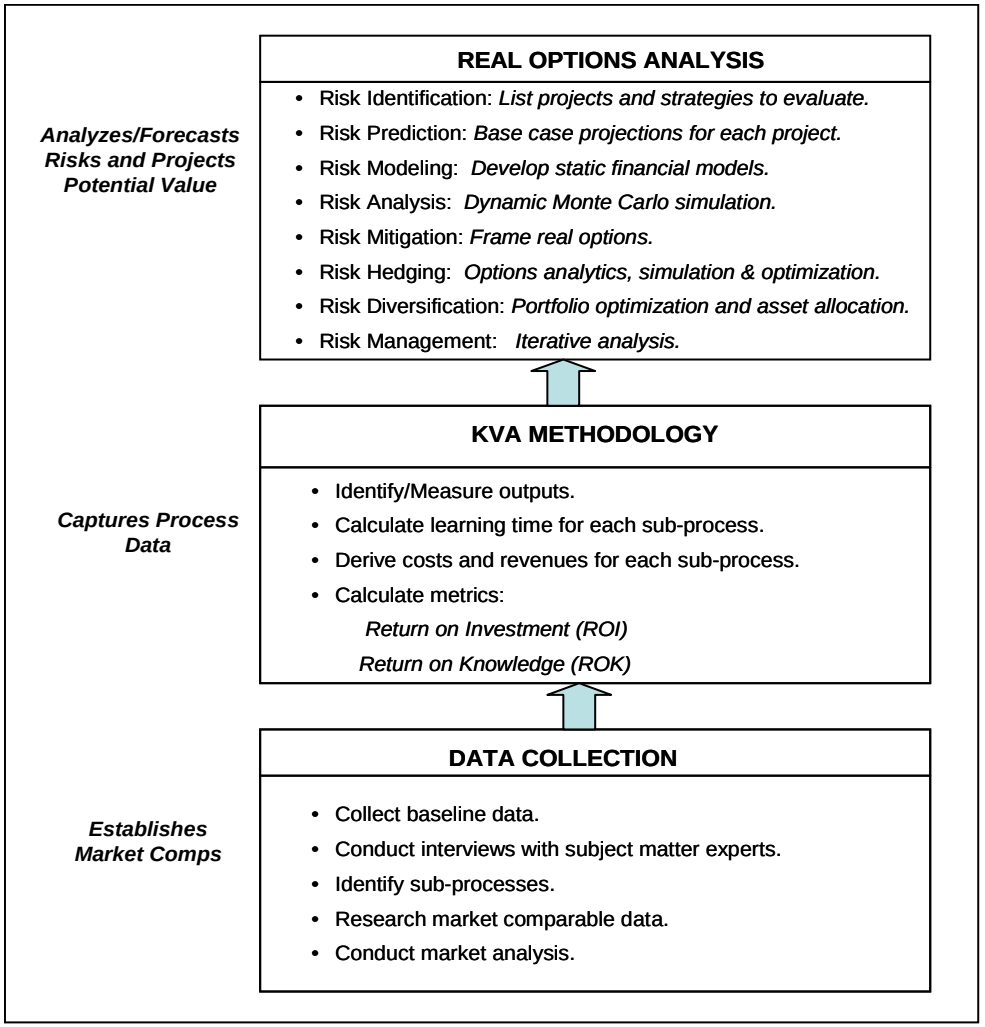
Introduction

- NPS conducted research in a proof-of-concept case study to quantify the potential benefits of Open Architecture on AEGIS.
- Knowledge-value Added/Real-options (KVA+RO) framework was applied to sustaining engineering in AEGIS software maintenance and upgrade process.
- KVA+RO framework provides decision-makers with systematic approach for analyzing benefits and assessing risks of potential IT acquisitions.
- Research conducted from acquirer and system-developer perspective to provide comprehensive view of entire system development lifecycle; prior research conducted from war-fighter perspective.

Knowledge Value Added and Real Options Analysis

- Measures value and cost of human and IT assets.
- Uses a “market comparables” valuation technique, to establish revenue surrogates for discounted cash flow estimates.
- Allows for use of powerful financial metrics in forecasting value of strategic options for replacing systems.
- Estimates value and risk of strategic options using real options analysis (Hammer, 2007 measures drivers of value and risk).

KVA+RO Valuation Framework



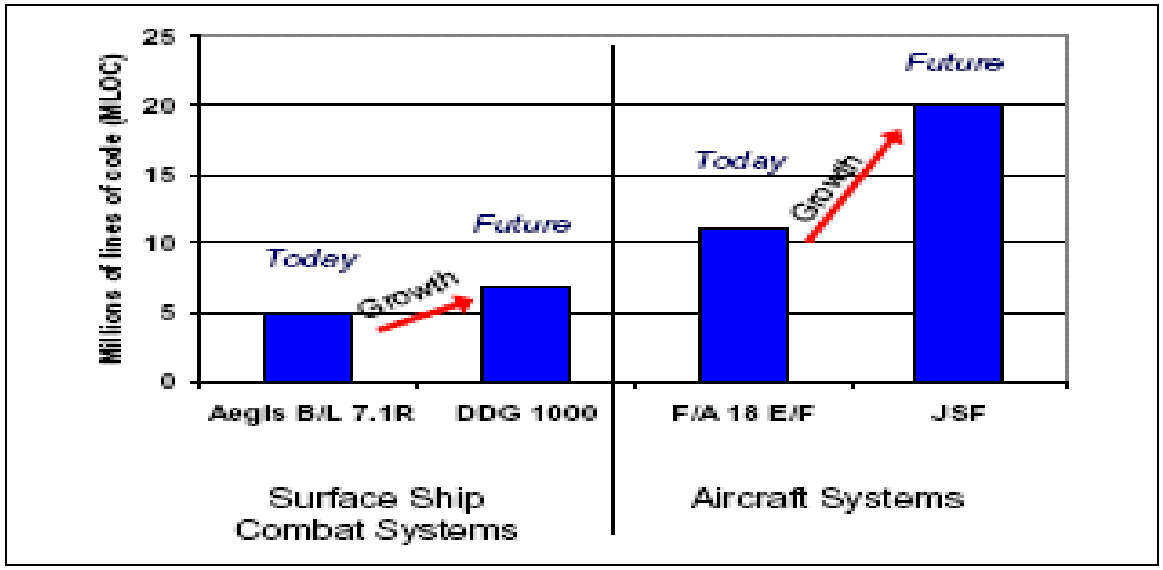
Case Study Methodology

- Analysis first conducted for one ship and then scaled up to include entire 84 AEGIS fleet of ships.
- Data used in analysis derived from interviews with Subject-matter Experts (SME's), surveys and secondary research.
- KVA methodology was first applied in Phase 1 of research under two scenarios: As-is and To-be.
- Real-options analysis was conducted in Phase 2 on several three scenarios to assess risks associated with potential strategies for AEGIS software maintenance and upgrade process.

The Challenge

- Software is an increasingly important functionality in Naval systems.
- For example, the size of the DDG 1000 combat system is expected to increase 35% to almost 1.8 MSLOC—larger than the AEGIS Baseline 7.1R

Size of Typical Naval Combat System

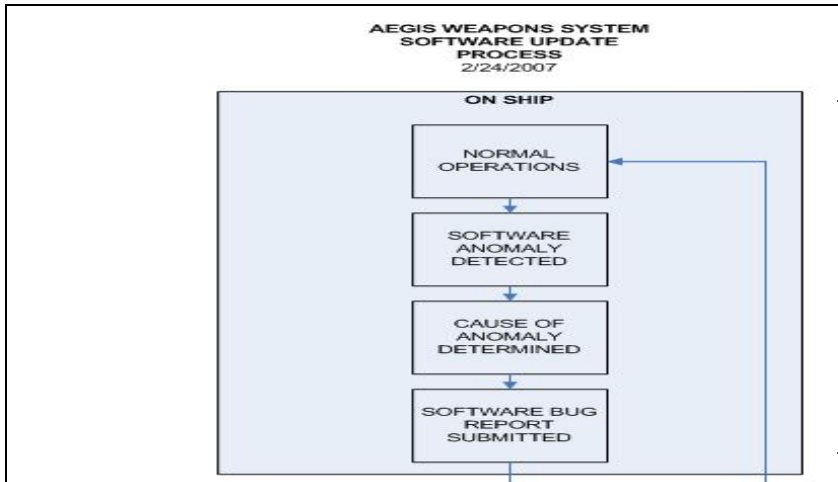


Source: Horvitz, E., Katz, D.J., Rumpf, R.L., Shrobe, H., Smith, T.B., Webber, G.E., Williamson, W.E., Winston, P.H., Wolbarsht, James L., (2006, July). ,Software Intensive Systems, , United States Naval Research Advisory Committee (NRAC) Panel on SOFTWARE INTENSIVE SYSTEMS. [www.onr.navy.mil/nrac/docs/2006_rpt_software_intensive_systems.pdf] Retrieved July 15, 2007.

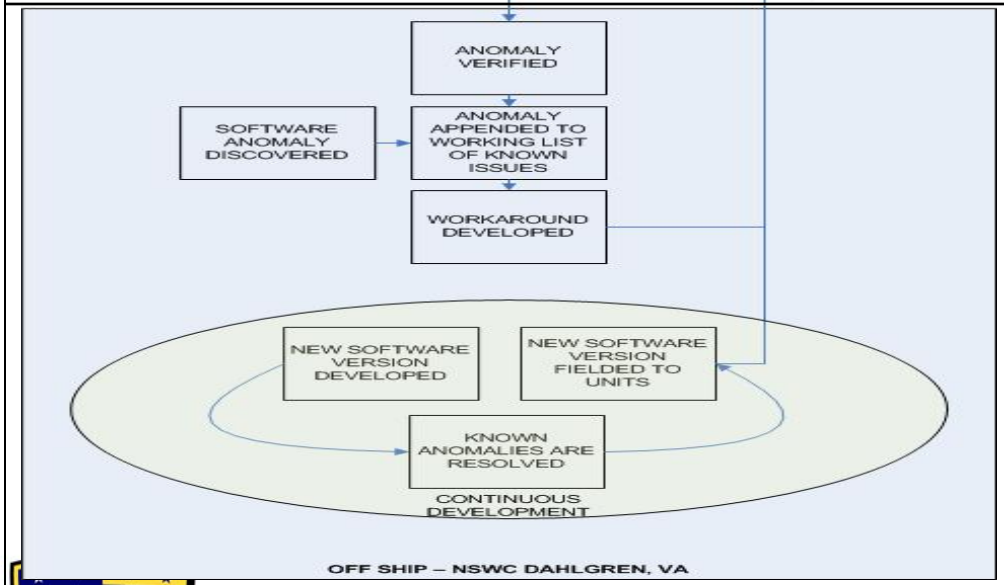
AEGIS Software Maintenance and Upgrade Process

- AEGIS software maintenance and upgrade process very complex involving large number of processes in four main phases (requirements definition, design, test and implementation/installation).
- Software maintenance and upgrade process involves many sub-processes in each one of its main processes.
- Entire AEGIS software upgrade lifecycle is intended to take 18 months; typically takes closer to 24 months due to problems found during testing phase or certification failures.

AEGIS Software Maintenance and Update Process
On-Ship and Off-Ship



- Conducted aboard AEGIS-equipped US Naval vessels by Surface Warfare fleet personnel, various support personnel (including contractors).
- Problems not found in testing phase of the process, installation and on-ship testing of the fielded AEGIS software update are identified.
- Two different departments detect AEGIS equipment and software failures and analyze effects on mission capability.



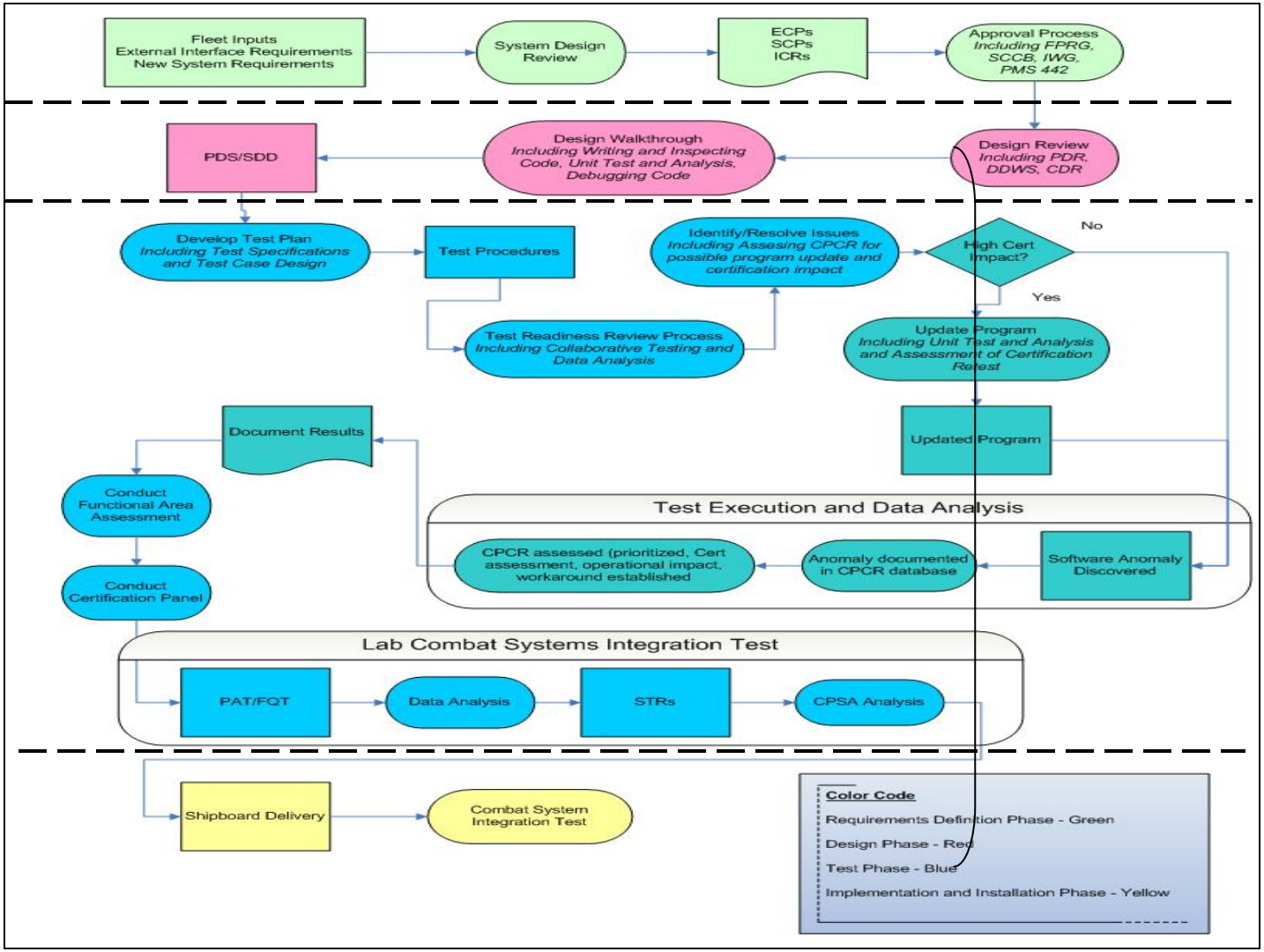
- Conducted at the Naval Surface Warfare Center, Dahlgren, VA.
- Primarily deals with three phases (requirements-definition, design and testing).

AEGIS Off-Ship Sub-Processes

Requirements/ Definitions Phase

Design Phase

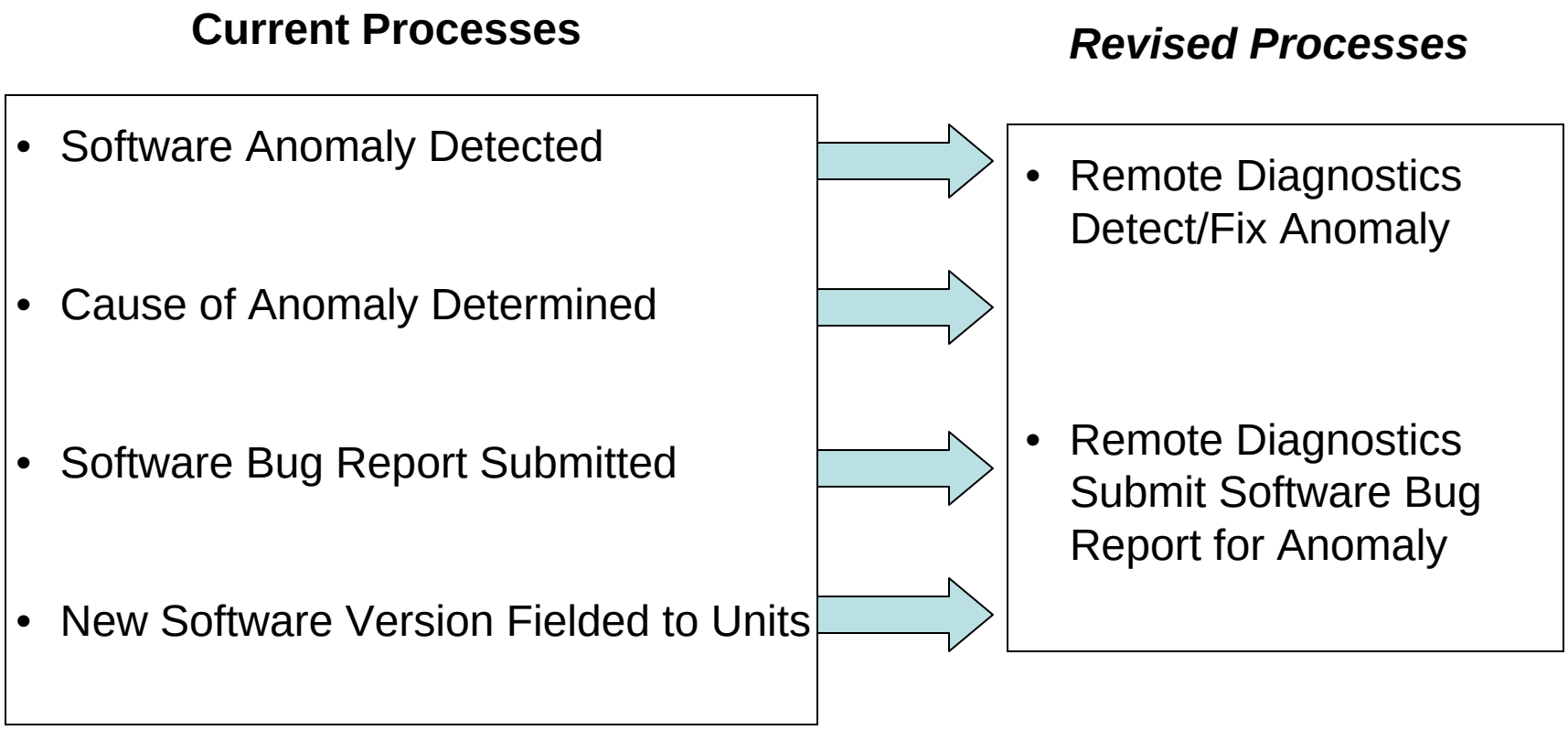
Test Phase



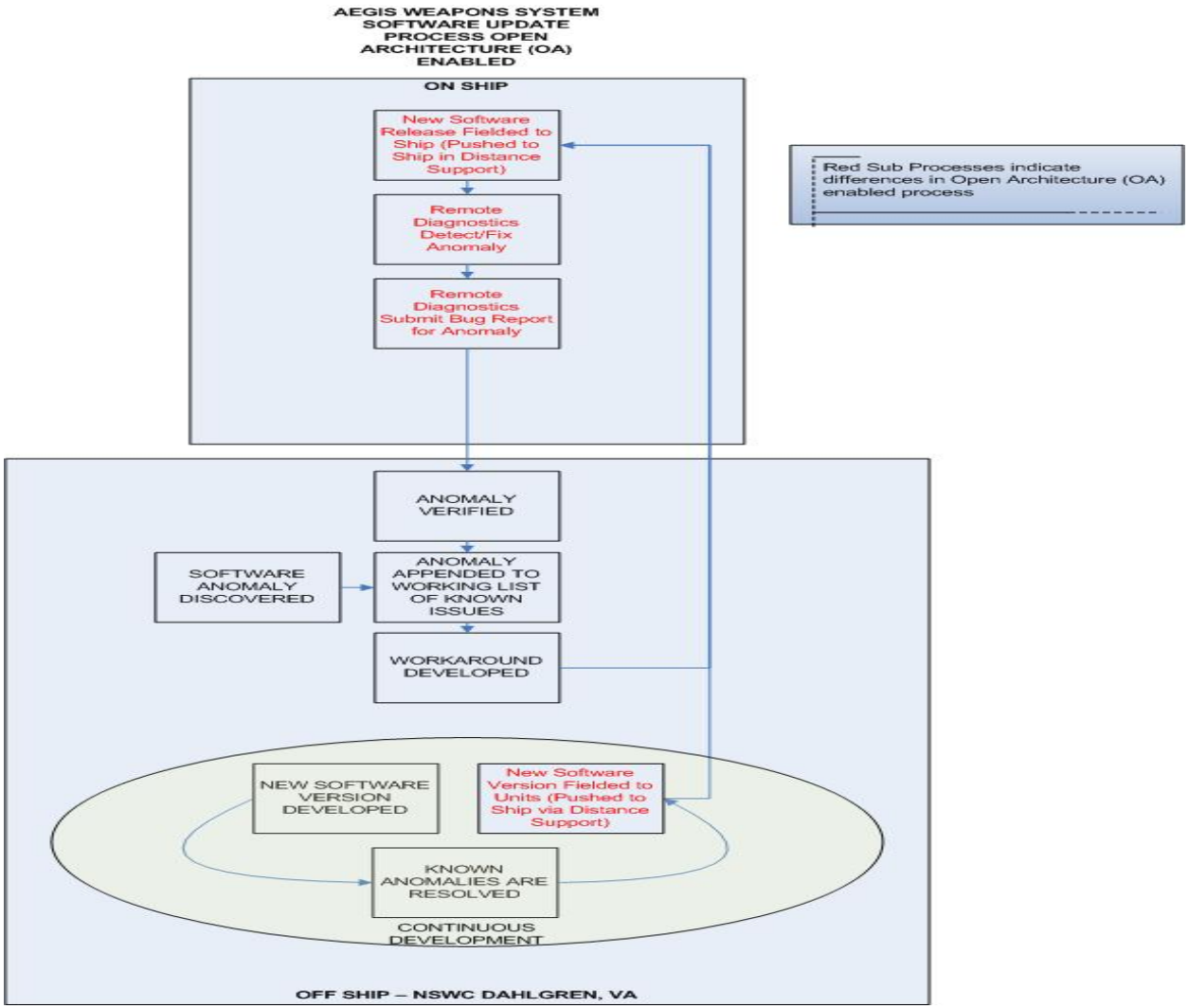
KVA Methodology Process Steps

1. Identify core processes and sub-processes.
2. Establish common units and level of complexity to measure learning time.
3. Calculate learning time (i.e., knowledge surrogate) to execute each sub-process.
4. Designate sampling time period long enough to capture representative sample of the core processes' final product or services output.
5. Multiply learning time for each sub-process by number of times sub-process executes during sample period.
6. Calculate cost to execute knowledge (learning time and process instructions) to determine process costs.
7. Calculate ROK (ROK= Revenue/Cost) and ROI (ROK= Revenue-Cost/Cost).

Case Study Results: Potential Impact of OA



Case Study Results: Revised Processes



Case Study Results: Cost, ROI and Revenues

- Costs for one ship decrease $365,105; costs for all ships decrease by $26,543,825 per year.
- Return on investment for one ship increases from 69% to 789%; ROI for all ships increases from 320% to 72,287%.
- Revenues (benefits) for one ship increase $2,488,179 to $3,837,931; revenues for all ships increase $209,007,032 to $322,386,181.

Case Study Results: Costs Savings

Costs for ONE Ship

Process/*Revised Process*	As-is	To-be	Potential Savings
Software Anomaly Detected ***New Release Fielded (Push to Ship via Distance Support)***	$14,301	$7,150	
Cause of Anomaly Determined ***Remote Diagnostics Detect/Fix Anomaly***	$251,597	$50,319	
Software Bug Report Submitted ***Remote Diagnostics Submit Software Bug Report for Anomaly***	$1,430	$1,430	
Anomaly Verified	$17,021	$17,021	
Anomaly Appended to Working List of Known Issues	$1,307	$1,307	
Workaround Developed	$17,021	$17,021	
New Software Version Developed	$236,750	$236,750	
Known Anomalies are Resolved	$100,639	$100,639	
New Software Version Fielded to Units	$156,840	$163	
Totals	**$796,907**	**$431,802**	***$365,105***

Costs for ALL Ships

Process/Revised Process	As-is	To-be	Potential Savings
Software Anomaly Detected *New Release Fielded (Push to Ship via Distance Support)*	$14,301	$7,150	
Cause of Anomaly Determined *Remote Diagnostics Detect/Fix Anomaly*	$251,597	$50,319	
Software Bug Report Submitted *Remote Diagnostics Submit Software Bug Report for Anomaly*	$1,430	$1,430	
Anomaly Verified	$17,021	$17,021	
Anomaly Appended to Working List of Known Issues	$1,307	$1,307	
Workaround Developed	$17,021	$17,021	
New Software Version Developed	$236,750	$236,750	
Known Anomalies are Resolved	$100,639	$100,639	
New Software Version Fielded to Units	26,349,120	$13,723	
Totals	**$26,989,187**	**$445,362**	***$26,543,825***

Case Study Results: ROI

ROI For ONE Ship

Process/Revised Process	As-is	To-be
Software Anomaly Detected *New Release Fielded (Push to Ship via Distance Support)*	297%	3874%
Cause of Anomaly Determined *Remote Diagnostics Detect/Fix Anomaly*	236%	4605%
Software Bug Report Submitted *Remote Diagnostics Submit Software Bug Report for Anomaly*	2108%	39636%
Anomaly Verified	234%	234%
Anomaly Appended to Working List of Known Issues	1188%	1188%
Workaround Developed	78%	78%
New Software Version Developed	-36%	-36%
Known Anomalies are Resolved	-41%	-41%
New Software Version Fielded to Units	-36%	185408%
Totals	**69%**	**789%**

ROI For ALL Ships

Process/Revised Process	As-is	To-be
Software Anomaly Detected *New Release Fielded (Push to Ship via Distance Support)*	33278%	333681%
Cause of Anomaly Determined *Remote Diagnostics Detect/Fix Anomaly*	28133%	395159%
Software Bug Report Submitted *Remote Diagnostics Submit Software Bug Report for Anomaly*	185334%	3337713%
Anomaly Verified	27943%	27943%
Anomaly Appended to Working List of Known Issues	108113%	108113%
Workaround Developed	14856%	14856%
New Software Version Developed	5277%	5277%
Known Anomalies are Resolved	4841%	4841%
New Software Version Fielded to Units	-68%	185408%
Totals	**320%**	**72287%**

Case Study KVA Results: Revenues

Revenues For One Ship

Process/*Revised Process*	As-is	To-be	Difference (As-is, To-be)
Software Anomaly Detected *New Release Fielded (Push to Ship via Distance Support)*	$56,826	$284,131	
Cause of Anomaly Determined *Remote Diagnostics Detect/Fix Anomaly*	$845,629	$2,367,761	
Software Bug Report Submitted *Remote Diagnostics Submit Software Bug Report for Anomaly*	$31,570	$568,262	
Anomaly Verified	$56,826	$56,826	
Anomaly Appended to Working List of Known Issues	$16,837	$16,837	
Workaround Developed	$30,307	$30,307	
New Software Version Developed	$151,537	$151,537	
Known Anomalies are Resolved	$59,194	$59,194	
New Software Version Fielded to Units	$101,024	$303,073	
Totals	**$1,349,752**	**$3,837,931**	***$2,488,179***

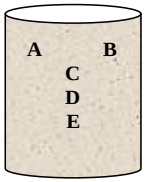
Revenues For ALL Ships

Process/*Revised Process*	As-is	To-be	Difference (As-is, To-be)
Software Anomaly Detected *New Release Fielded (Push to Ship via Distance Support)*	$4,773,407	$23,867,035	
Cause of Anomaly Determined *Remote Diagnostics Detect/Fix Anomaly*	$71,032,841	$198,891,956	
Software Bug Report Submitted *Remote Diagnostics Submit Software Bug Report for Anomaly*	$2,651,893	$47,734,069	
Anomaly Verified	$4,773,407	$4,773,407	
Anomaly Appended to Working List of Known Issues	$1,414,343	$1,414,343	
Workaround Developed	$2,545,817	$2,545,817	
New Software Version Developed	$12,729,085	$12,729,085	
Known Anomalies are Resolved	$4,972,299	$4,972,299	
New Software Version Fielded to Units	$8,486,057	$25,458,170	***$209,007,032***

Real-options Analysis

RISK IDENTIFICATION

1. List of projects and strategies to evaluate



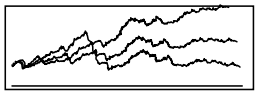
Start with a list of projects or strategies to be evaluated… these projects have already been through qualitative screening

RISK PREDICTION

2. Base case projections for each project

Historical Data Gathering

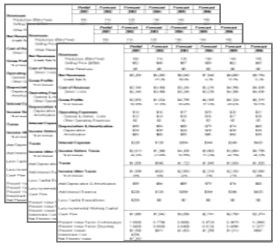
Time Series Forecasting



…will the assistance of time-series forecasting and historical data…

RISK MODELING

3. Develop static financial models with KVA data



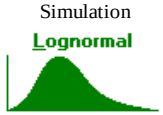
…the user generates a traditional series of static base case financial (discounted cash flow) models for each project…

Traditional analysis stops here!

RISK ANALYSIS

4. Dynamic Monte Carlo simulation

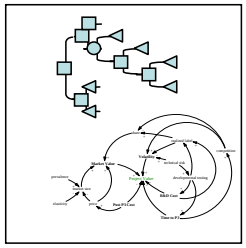
Simulation



…sensitivity and scenario analysis coupled with Monte Carlo simulation is added to the analysis and the financial model outputs become inputs into the real options analysis…

RISK MITIGATION

5. Framing Real Options

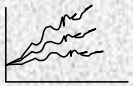


…the relevant projects are chosen for real options analysis and the project or portfolio real options are framed…

RISK HEDGING

6. Options analytics, simulation and optimization

Simulation



Lattice

Closed-Form Models

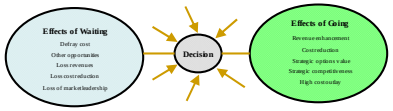
$$\frac{\delta S}{S} = \mu(\delta t) + \sigma\varepsilon\sqrt{\delta t}$$

…real options analytics are calculated through binomial lattices and closed-form partial-differential models with simulation…

RISK DIVERSIFICATION

7. Portfolio optimization and asset allocation

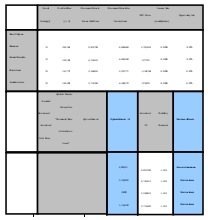
Optimization



…stochastic optimization is the next optional step if multiple projects exist that requires efficient asset allocation given some budgetary constraints… useful for strategic portfolio management…

RISK MANAGEMENT

8. Reports presentation and update analysis



…create reports, make decisions, and do it all again iteratively over time…

Real-Options Valuation Results: Strategies A-D

	Strategy A	Strategy B	Strategy C	Strategy D
STRATEGIC OPTION	**AS-IS (1)**	**TO-BE (W/out Changes in Fielding to Units)**	**TO-BE (1,3,4,5,6,7)**	**TO-BE (1,2,3,4,5,6,7)**
Total Strategic Value	$196M	$995M	$1.24B	1.48B
Volatility	10%	30%	60%	50%
Total Cost	$208M	$96M	$30M	$80M

Key:

1. As-is
2. Implement remote diagnostics/prognostics through ORTSTARS/Distance support, plus the ability of the crew to inject a trouble report through ORTSTARS/Distance support.
3. Number 2 plus providing software updates to the ship on media, then having the crew install with technician DS (remote) help. (Could also postulate a "sense and respond" sort of thing, in which a "local" tech is scheduled to the ship based on its availability and the update's arrival. Would count on local assets, not travel from Dahlgren...)
4. Number 3 plus notification of the ship that the update is available for download. Ship initiates download and installs with DS help.
5. Number 4, except that the ship is notified that updates are available. The on-ship operators tell DS they're ready, and the remote tech takes control and installs the update.
6. Number 4 except that the update is pushed to the ship, then cached until operators are ready to install. Ship installs with DS assistance if needed.
7. Final state in which the update is pushed to the ship and installs during slack time, notifying the ship and allowing operators to say "not now."

Research Implications

- Results from our research indicate that implementing OA could result in substantial cost savings, optimal return on investment and increased benefits.

- Software updates could be available via push or pull method with OA. In the pull method, user downloads and installs updates. With the push method, software is pushed to the network node remotely, thereby reducing onsite personnel while speeding up the upgrade process.

- New software updates could be fielded to the ship through in either method, resulting in reduced cycle-time fielding new software to its shipboard configuration.

- Remote diagnostics could also be performed to further reduce cycle-time.